

Claims

We claim:

1. A nitride semiconductor layer structure, comprising:
a buffer layer of a low-temperature-deposited nitride semiconductor material including AlN; and
a composite layer of a single-crystal nitride semiconductor material including AlN on the buffer layer, the composite layer including:
5 a first sub-layer adjacent the buffer layer, and
a second sub-layer over the first sub-layer, in which:
the single-crystal nitride semiconductor material has a first AlN molar fraction in the first sub-layer and a second AlN molar fraction in the second sub-layer,
10 the second AlN molar fraction being greater than the first AlN molar fraction.

2. The nitride semiconductor layer structure of claim 1, additionally comprising:
an additional composite layer of a single-crystal nitride semiconductor material, the additional composite layer including:
5 a first additional sub-layer, and
a second additional sub-layer; and
an active layer between the composite layer and the additional composite layer, in which:
the second additional sub-layer is closer to the active layer than is the
10 first additional sub-layer, and
the single-crystal nitride semiconductor material of the additional composite layer has a first additional AlN molar fraction in the first additional sub-layer and a second additional AlN molar fraction in the second additional sub-layer, the second additional AlN molar fraction being greater than the first
15 additional AlN molar fraction.

3. The nitride semiconductor layer structure of claim 1, in which the second AlN molar fraction differs from the first AlN molar fraction by no more than 0.1.

4. The nitride semiconductor layer structure of claim 3, in which the second AlN molar fraction differs from the first AlN molar fraction by more than 0.03.

5. The nitride semiconductor layer structure of claim 1, additionally comprising a sapphire substrate under the buffer layer.

6. The nitride semiconductor layer structure of claim 1, additionally comprising a substrate under the buffer layer, the substrate including one of SiC and GaN.

7. The nitride semiconductor layer structure of claim 1, additionally comprising a substrate structure under the buffer layer, the substrate structure including:

a substrate;

a layer of GaN; and

a layer of a low-temperature-deposited semiconductor material sandwiched between the substrate and the layer of GaN.

8. The nitride semiconductor layer structure of claim 1, in which the low-temperature-deposited semiconductor material of the buffer layer and the single-crystal nitride semiconductor material of the composite layer are doped with the same dopant.

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9. The nitride semiconductor layer structure of claim 1, in which:
the buffer layer has a thickness ≤ 100 nm;
the low-temperature-deposited nitride semiconductor material of the
buffer layer is $\text{Al}_y\text{Ga}_{1-y}\text{N}$ in which ($0 < y \leq 1$);
5 the single-crystal nitride semiconductor material of the composite layer
is $\text{Al}_x\text{Ga}_{1-x}\text{N}$; and
the second sub-layer has a thickness of at least 600 nm and the second
AlN molar fraction x is in the range ($0.05 < x \leq 1$).

10. The nitride semiconductor layer structure of claim 1, in which the
low-temperature-deposited nitride semiconductor material of the buffer layer
has an AlN molar fraction of at least 0.01.

11. The nitride semiconductor layer structure of claim 10, in which the
single-crystal nitride semiconductor material of the composite layer has an AlN
molar fraction at least 0.03.

12. The nitride semiconductor layer structure of claim 1, in which:
the composite layer additionally includes a gradient sub-layer between
the first sub-layer and the second sub-layer; and
the AlN molar fraction of the single-crystal nitride semiconductor
5 material of the composite layer changes from the first AlN molar fraction to
the second AlN molar fraction in the gradient sub-layer.

13. The nitride semiconductor layer structure of claim 12, in which AlN
molar fraction of the single-crystal nitride semiconductor material of the
composite layer changes from the first AlN molar fraction to the second AlN
molar fraction one of (a) linearly and (b) parabolically in the gradient sub-
5 layer.

14. A nitride semiconductor laser, comprising:
a portion of a nitride semiconductor layer structure according to any
one of the previous claims;
an optical waveguide layer over the composite layer; and
5 an active layer over the optical waveguide layer.

15. The nitride semiconductor laser of claim 14, in which:
the second sub-layer has a thickness; and
at least one of the thickness of the second sub-layer and the second AlN
molar fraction has a value at which the laser generates light having a far-field
5 pattern that exhibits a single peak.

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